General

Guideline Title

2011 update to the Society of Thoracic Surgeons and the Society of Cardiovascular Anesthesiologists blood conservation clinical practice guidelines.

Bibliographic Source(s)

Ferraris VA, Brown JR, Despotis GJ, Hammon JW, Reece TB, Saha SP, Song HK, Clough ER, Shore-Lesserson LJ, Goodnough LT, Mazer CD, Shander A, Stafford-Smith M, Waters J, Baker RA, Dickinson TA, Fitzgerald DJ, Likosky DS, Shann KG. 2011 update to the Society of Thoracic Surgeons and the Society of Cardiovascular Anesthesiologists blood conservation clinical practice guidelines. Ann Thorac Surg. 2011 Mar;91(3):944-82. [404 references] PubMed

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Society of Thoracic Surgeons Blood Conservation Guideline Task Force, Ferraris VA, Ferraris SP, Saha SP, Hessel EA 2nd, Haan CK, Royston BD, Bridges CR, Higgins RS, Despotis G, Brown JR; Society of Cardiovascular Anesthesiologists Special Task Force on Blood Transfusion, Spiess BD, Shore-Lesserson L, Stafford-Smith M, Mazer CD, Bennett-Guerrero E, Hill SE, Body S. Ann Thorac Surg. 2007 May;83(5 Suppl):S27-86.

Regulatory Alert

FDA Warning/Regulatory Alert

Note from the National Guideline Clearinghouse: This guideline references a drug(s) for which important revised regulatory and/or warning information has been released.

Drug Withdrawal

- May 14, 2008 WITHDRAWAL: Trasylol (aprotinin injection) : Following publication of the Blood conservation using antifibrinolytics: A randomized trial in a cardiac surgery population (BART) study in the May 14, 2008 online issue of The New England Journal of Medicine, Bayer Pharmaceuticals notified the U.S. Food and Drug Administration (FDA) of their intent to remove all remaining supplies of Trasylol from hospital pharmacies and warehouses. Because Trasylol has been shown to decrease the need for red blood cell transfusions in patients undergoing coronary artery bypass surgery, future supplies of Trasylol will continue to be available through the company as an investigational drug under a special treatment protocol.

Recommendations

Major Recommendations

The American College of Cardiology/American Heart Association (ACCF/AHA) classification of the recommendations (classes I-III) and the levels of evidence (A-C) are defined at the end of the "Major Recommendations" field.

Table 1 summarizes the new and revised blood conservation recommendations for patients undergoing cardiac operations based on available evidence. The full text that describes the evidence base behind each of these recommendations is available in the original guideline document.

Table 2 is a summary of the previously published 2007 guideline recommendations that the writing group feels still have validity and provide meaningful suggestions for blood conservation.

Table 1. New and Revised 2011 Recommendations for Blood Conservation in Patients Undergoing Cardiac Procedures with Differing Risks

Blood Conservation Intervention	Class of Recommendation (Level of Evidence)
Preoperative interventions	
Drugs that inhibit the platelet P2Y12 receptor should be discontinued before operative coronary revascularization (either on pump or off pump), if possible. The interval between drug discontinuation and operation varies depending on the drug pharmacodynamics, but may be as short as 3 days for irreversible inhibitors of the P2Y12 platelet receptor.	I (B)
Point-of-care testing for platelet adenosine diphosphate responsiveness might be reasonable to identify clopidogrel nonresponders who are candidates for early operative coronary revascularization and who may not require a preoperative waiting period after clopidogrel discontinuation.	IIb (C)
Routine addition of P2Y12 inhibitors to aspirin therapy early after coronary artery bypass graft (CABG) may increase the risk of reexploration and subsequent operation and is not indicated based on available evidence except in those patients who satisfy criteria for American College of Cardiology/American Heart Association (ACC/AHA) guideline-recommended dual antiplatelet therapy (e.g., patients presenting with acute coronary syndromes or those receiving recent drug eluting coronary stents).	III (B)
It is reasonable to use preoperative erythropoietin (EPO) plus iron, given several days before cardiac operation, to increase red cell mass in patients with preoperative anemia, in candidates for operation who refuse transfusion (e.g., Jehovah's Witness), or in patients who are at high risk for postoperative anemia. However, chronic use of erythropoietin is associated with thrombotic cardiovascular events in renal failure patients suggesting caution for this therapy in individuals at risk for such events (e.g., coronary revascularization patients with unstable symptoms).	IIa (B)
Recombinant human erythropoietin may be considered to restore red blood cell volume in patients also undergoing autologous preoperative blood donation before cardiac procedures. However, no large-scale safety studies for use of this agent in cardiac surgical patients are available, and must be balanced with the potential risk of thrombotic cardiovascular events (e.g., coronary revascularization patients with unstable symptoms).	IIb (A)
Drugs used for intraoperative blood management	
Lysine analogues—epsilon-aminocaproic acid (Amicar) and tranexamic acid (Cyklokapron)—reduce total blood loss and decrease the number of patients who require blood transfusion during cardiac procedures and are indicated for blood conservation.	I (A)
High-dose (Trasylol, 6 million kallikrein inactivation unit [KIU]) and low-dose (Trasylol, 1 million KIU) aprotinin reduce the number of adult patients requiring blood transfusion, total blood loss, and reexploration in patients undergoing cardiac surgery but are not indicated for routine blood conservation because the risks outweigh the benefits. High-dose aprotinin administration is associated with a 49% to 53% increased risk of 30-day death and 47% increased risk of renal dysfunction in adult patients. No similar controlled data are available for younger patient populations including infants and children.	III (A)

Blood Conservation Intervention	Class of Recommendation (Level of Evidence)
Blood derivatives used in blood management	
Plasma transfusion is reasonable in patients with serious bleeding in context of multiple or single coagulation factor deficiencies when safer fractionated products are not available.	IIa (B)
Preoperative interventions	
For urgent warfarin reversal, administration of prothrombin complex concentrate (PCC) is preferred but plasma transfusion is reasonable when adequate levels of factor VII are not present in prothrombin complex concentrate.	IIa (B)
Drugs that inhibit the platelet P2Y12 receptor should be discontinued before nonemergent cardiac surgery (either on pump or off pump), if possible. The interval between drug discontinuation and operation varies depending on the drug pharmacodynamics, but may be as short as 3 days for irreversible inhibitors of the P2Y12 platelet receptor.	I (B)
Transfusion of plasma may be considered as part of a massive transfusion algorithm in bleeding patients requiring substantial amounts of red-blood cells.	IIb (B)
Point-of-care testing for platelet adenosine diphosphate responsiveness might be reasonable to identify clopidogrel nonresponders who are candidates for early operative coronary revascularization and who may not require a preoperative waiting period after clopidogrel discontinuation.	IIb (C)
Prophylactic use of plasma in cardiac operations in the absence of coagulopathy is not indicated, does not reduce blood loss and exposes patients to unnecessary risks and complications of allogeneic blood component transfusion.	III (A)
Plasma is not indicated for warfarin reversal in the absence of bleeding.	III (A)
Routine addition of P2Y12 inhibitors to aspirin therapy early after coronary artery bypass graft (CABG) may increase the risk of reoperation for hemostasis and is not indicated because of available evidence except in those patients who satisfy criteria for American College of Cardiology/American Heart Association (ACC/AHA) guideline-recommended dual antiplatelet therapy (e.g., patients presenting with acute coronary syndromes or those receiving recent drug eluting coronary stents).	III (B)
Use of factor XIII may be considered for clot stabilization after cardiac procedures requiring cardiopulmonary bypass and is not indicated because of available evidence except in those patients who satisfy criteria for American College of Cardiology/American Heart Association (ACC/AHA) guideline-recommended dual antiplatelet therapy (e.g., patients presenting with acute coronary syndromes or those receiving recent drug eluting coronary stents).	IIb (C)
When allogeneic blood transfusion is needed, it is reasonable to use leukoreduced donor blood, if available. Benefits of leukoreduction may be more pronounced in patients undergoing cardiac procedures.	IIa (B)
It is reasonable to use preoperative erythropoietin (EPO) plus iron, given several days before cardiac operation, to increase red cell mass in patients with preoperative anemia, in candidates for operation who refuse transfusion (e.g., Jehovah's Witness), or in patients who are at high risk for postoperative anemia. However, chronic use of erythropoietin is associated with thrombotic cardiovascular events in renal failure patients suggesting caution for this therapy in individuals at risk for such events (e.g., coronary revascularization patients with unstable symptoms).	IIa (B)
Use of intraoperative platelet plasmapheresis is reasonable to assist with blood conservation strategies as part of a multimodality program in high-risk patients if an adequate platelet yield can be reliably obtained.	IIa (A)
Use of recombinant factor VIIa concentrate may be considered for the management of intractable nonsurgical bleeding that is unresponsive to routine hemostatic therapy after cardiac procedures using cardiopulmonary bypass (CPB).	IIb (B)
Recombinant human erythropoietin may be considered to restore red blood cell volume in patients also undergoing autologous preoperative blood donation before cardiac procedures. However, no large-scale safety studies for use of this agent in cardiac surgical patients are available, and must be balanced with the potential risk of thrombotic cardiovascular events (e.g., coronary revascularization patients with unstable symptoms).	IIb (A)
Antithrombin III (AT) concentrates are indicated to reduce plasma transfusion in patients with antithrombin III-mediated heparin resistance immediately before cardiopulmonary bypass.	I (A)
Administration of antithrombin III concentrates is less well established as part of a multidisciplinary blood management protocol in high-risk patients who may have antithrombin III depletion or in some, but not all, patients who are unwilling to accept blood products for religious reasons.	IIb (C)
Drugs used for intraoperative blood management	
Lysine analogues—epsilon aminocaproic acid (Amicar) and tranexamic acid (Cyklokapron)—reduce total blood loss and decrease the number of patients who require blood transfusion during cardiac procedures and are indicated for blood conservation.	I (A)
Use of factor IX concentrates, or combinations of clotting factor complexes that include factor IX, may be considered in patients with hemophilia B or who refuse primary blood component transfusion for religious reasons (e.g., Jehovah's Witness) and who require cardiac operations.	IIb (C)
Blood salvage interventions	
High-dose (Trasylol, 2 million kallikrein inactivation unit [KIU]) and low-dose (Trasylol, 1 million KIU) aprotinin reduce the number of adult patients requiring blood transfusion, total blood loss, and reexploration in patients undergoing cardiac surgery but are not indicated for routine blood conservation because the risks outweigh the benefits. High-dose aprotinin administration is associated with a 49% to 53% increased risk of 30-day death and 47% increased risk of renal dysfunction in adult patients. No similar controlled data are available for younger patient populations including infants and children.	III (A)
In high-risk patients with known malignancy who require CPB, blood salvage using centrifugation of salvaged blood from the operative field may be considered since substantial data supports benefit in patients without malignancy and new evidence suggests worsened outcome when allogeneic transfusion is required in patients with malignancy.	IIb (B)
Consensus suggests that some form of pump salvage and reinfusion of residual pump blood at the end of CPB is reasonable as part of a blood management program to minimize blood transfusion.	IIa (C)
Blood derivatives used in blood management	
Centrifugation of pump-salvaged blood, instead of direct infusion, is reasonable for minimizing post-CPB allogeneic red blood cell (RBC) transfusion.	IIa (A)
Plasma transfusion is reasonable in patients with serious bleeding in context of multiple or single coagulation factor deficiencies when safer fractionated products are not available.	IIa (B)
Minimally invasive procedures	
For urgent warfarin reversal, administration of prothrombin complex concentrate (PCC) is preferred but plasma transfusion is reasonable when adequate levels of factor VII are not present in prothrombin complex concentrate.	IIa (B)
Transfusion of plasma may be considered as part of a massive transfusion algorithm in bleeding patients requiring substantial amounts of red-blood cells.	IIb (B)
Prophylactic use of plasma in cardiac operations in the absence of coagulopathy is not indicated, does not reduce blood loss and exposes patients to unnecessary risks and complications of allogeneic blood component transfusion.	III (A)
Plasma is not indicated for warfarin reversal in the absence of bleeding.	III (B)
Use of factor XIII may be considered for clot stabilization after cardiac procedures requiring cardiopulmonary bypass	IIb (C)

Blood derivatives used in blood management
Plasma transfusion is reasonable in patients with serious bleeding in context of multiple or single coagulation factor deficiencies when safer fractionated products are not available.
Preoperative interventions
For urgent warfarin reversal, administration of prothrombin complex concentrate (PCC) is preferred but plasma transfusion is reasonable when adequate levels of factor VII are not present in prothrombin complex concentrate.
Drugs that inhibit the platelet P2Y12 receptor should be discontinued before nonemergent cardiac surgery (either on pump or off pump), if possible. The interval between drug discontinuation and operation varies depending on the drug pharmacodynamics, but may be as short as 3 days for irreversible inhibitors of the P2Y12 platelet receptor.
Transfusion of plasma may be considered as part of a massive transfusion algorithm in bleeding patients requiring substantial amounts of red-blood cells.
Point-of-care testing for platelet adenosine diphosphate responsiveness might be reasonable to identify clopidogrel nonresponders who are candidates for early operative coronary revascularization and who may not require a preoperative waiting period after clopidogrel discontinuation.
Prophylactic use of plasma in cardiac operations in the absence of coagulopathy is not indicated, does not reduce blood loss and exposes patients to unnecessary risks and complications of allogeneic blood component transfusion.
Plasma is not indicated for warfarin reversal in the absence of bleeding.
Routine addition of P2Y12 inhibitors to aspirin therapy early after coronary artery bypass graft (CABG) may increase the risk of reoperation for hemostasis and is not indicated because of available evidence except in those patients who satisfy criteria for American College of Cardiology/American Heart Association (ACC/AHA) guideline-recommended dual antiplatelet therapy (e.g., patients presenting with acute coronary syndromes or those receiving recent drug eluting coronary stents).
Use of factor XIII may be considered for clot stabilization after cardiac procedures requiring cardiopulmonary bypass and is not indicated because of available evidence except in those patients who satisfy criteria for American College of Cardiology/American Heart Association (ACC/AHA) guideline-recommended dual antiplatelet therapy (e.g., patients presenting with acute coronary syndromes or those receiving recent drug eluting coronary stents).
When allogeneic blood transfusion is needed, it is reasonable to use leukoreduced donor blood, if available. Benefits of leukoreduction may be more pronounced in patients undergoing cardiac procedures.
It is reasonable to use preoperative erythropoietin (EPO) plus iron, given several days before cardiac operation, to increase red cell mass in patients with preoperative anemia, in candidates for operation who refuse transfusion (e.g., Jehovah's Witness), or in patients who are at high risk for postoperative anemia. However, chronic use of erythropoietin is associated with thrombotic cardiovascular events in renal failure patients suggesting caution for this therapy in individuals at risk for such events (e.g., coronary revascularization patients with unstable symptoms).
Use of intraoperative platelet plasmapheresis is reasonable to assist with blood conservation strategies as part of a multimodality program in high-risk patients if an adequate platelet yield can be reliably obtained.
Use of recombinant factor VIIa concentrate may be considered for the management of intractable nonsurgical bleeding that is unresponsive to routine hemostatic therapy after cardiac procedures using cardiopulmonary bypass (CPB).
Recombinant human erythropoietin may be considered to restore red blood cell volume in patients also undergoing autologous preoperative blood donation before cardiac procedures. However, no large-scale safety studies for use of this agent in cardiac surgical patients are available, and must be balanced with the potential risk of thrombotic cardiovascular events (e.g., coronary revascularization patients with unstable symptoms).
Antithrombin III (AT) concentrates are indicated to reduce plasma transfusion in patients with antithrombin III-mediated heparin resistance immediately before cardiopulmonary bypass.
Administration of antithrombin III concentrates is less well established as part of a multidisciplinary blood management protocol in high-risk patients who may have antithrombin III depletion or in some, but not all, patients who are unwilling to accept blood products for religious reasons.
Drugs used for intraoperative blood management
Lysine analogues—epsilon aminocaproic acid (Amicar) and tranexamic acid (Cyklokapron)—reduce total blood loss and decrease the number of patients who require blood transfusion during cardiac procedures and are indicated for blood conservation.
Use of factor IX concentrates, or combinations of clotting factor complexes that include factor IX, may be considered in patients with hemophilia B or who refuse primary blood component transfusion for religious reasons (e.g., Jehovah's Witness) and who require cardiac operations.
Blood salvage interventions
High-dose (Trasylol, 2 million kallikrein inactivation unit [KIU]) and low-dose (Trasylol, 1 million KIU) aprotinin reduce the number of adult patients requiring blood transfusion, total blood loss, and reexploration in patients undergoing cardiac surgery but are not indicated for routine blood conservation because the risks outweigh the benefits. High-dose aprotinin administration is associated with a 49% to 53% increased risk of 30-day death and 47% increased risk of renal dysfunction in adult patients. No similar controlled data are available for younger patient populations including infants and children.
In high-risk patients with known malignancy who require CPB, blood salvage using centrifugation of salvaged blood from the operative field may be considered since substantial data supports benefit in patients without malignancy and new evidence suggests worsened outcome when allogeneic transfusion is required in patients with malignancy.
Consensus suggests that some form of pump salvage and reinfusion of residual pump blood at the end of CPB is reasonable as part of a blood management program to minimize blood transfusion.
Blood derivatives used in blood management
Centrifugation of pump-salvaged blood, instead of direct infusion, is reasonable for minimizing post-CPB allogeneic red blood cell (RBC) transfusion.
Plasma transfusion is reasonable in patients with serious bleeding in context of multiple or single coagulation factor deficiencies when safer fractionated products are not available.
Minimally invasive procedures
For urgent warfarin reversal, administration of prothrombin complex concentrate (PCC) is preferred but plasma transfusion is reasonable when adequate levels of factor VII are not present in prothrombin complex concentrate.
Transfusion of plasma may be considered as part of a massive transfusion algorithm in bleeding patients requiring substantial amounts of red-blood cells.
Prophylactic use of plasma in cardiac operations in the absence of coagulopathy is not indicated, does not reduce blood loss and exposes patients to unnecessary risks and complications of allogeneic blood component transfusion.
Plasma is not indicated for warfarin reversal in the absence of bleeding.
Use of factor XIII may be considered for clot stabilization after cardiac procedures requiring cardiopulmonary bypass

Off-pump coronary revascularization (OPCAB) is a reasonable strategy to reduce blood transfusion, provided that emergent conversion to on-pump coronary artery bypass graft is unlikely and the increased risk of graft closure is considered in weighing risks and benefits.

Routine use of cardioplegia techniques may be considered to minimize the volume of crystalloid cardioplegia administered as part of a multimodality blood conservation program, especially in fluid overload conditions like congestive heart failure.

Blood Conservation Intervention	Class of Recommendation (Level of Evidence)
Preoperative interventions	
Minicircuits (reduced priming volume in the minimized CPB circuit) reduce hemodilution and are indicated for blood conservation, especially in patients at high risk for adverse effects of hemodilution (e.g., pediatric patients and Jehovah's Witness patients).	I (A)
Drugs that inhibit the platelet P2Y12 receptor should be discontinued before operative coronary revascularization (either on-pump or off-pump), if possible. The interval between drug discontinuation and operation varies depending on the drug pharmacodynamics, but may be as short as 3 days for irreversible inhibitors of the P2Y12 platelet receptor.	I (B)
Vacuum-assisted venous drainage in conjunction with minicircuits may prove useful in limiting bleeding and blood transfusion as part of a multimodality blood conservation program.	IIb (C)
Point-of-care testing for platelet adenosine diphosphate responsiveness might be reasonable to identify clopidogrel nonresponders who are candidates for early operative coronary revascularization and who may not require a preoperative waiting period after clopidogrel discontinuation.	IIb (C)
Use of biocompatible CPB circuits may be considered as part of a multimodality program for blood conservation.	IIb (A)
Use of modified ultrafiltration is indicated for blood conservation and reducing postoperative blood loss in adult and pediatric cardiac operations using CPB.	I (A)
Routine addition of P2Y12 inhibitors to aspirin therapy early after coronary artery bypass graft (CABG) may increase the risk of reexploration and subsequent operation and is not indicated based on available evidence except in those patients who satisfy criteria for American College of Cardiology/American Heart Association (ACC/AHA) guideline-recommended dual antiplatelet therapy (e.g., patients presenting with acute coronary syndromes or those receiving recent drug eluting coronary stents).	III (B)
Benefit of the use of conventional or zero balance ultrafiltration is not well established for blood conservation and reducing postoperative blood loss in adult cardiac operations.	IIb (A)
Available leukocyte filters placed on the CPB circuit for leukocyte depletion are not indicated for perioperative blood conservation and may prove harmful by activating leukocytes during CPB.	III (B)
It is reasonable to use preoperative erythropoietin (EPO) plus iron, given several days before cardiac operation, to increase red cell mass in patients with preoperative anemia, in candidates for operation who refuse transfusion (e.g., Jehovah's Witness), or in patients who are at high risk for postoperative anemia. However, chronic use of erythropoietin is associated with thrombotic cardiovascular events in renal failure patients suggesting caution for this therapy in individuals at risk for such events (e.g., coronary revascularization patients with unstable symptoms).	IIa (B)
Topical hemostatic agents	
Topical hemostatic agents that employ localized compression or provide wound sealing may be considered to provide local hemostasis at anastomotic sites as part of a multimodal blood management program.	IIb (C)
Recombinant human erythropoietin may be considered to restore red blood cell volume in patients also undergoing autologous preoperative blood donation before cardiac procedures. However, no large-scale safety studies for use of this agent in cardiac surgical patients are available, and must be balanced with the potential risk of thrombotic cardiovascular events (e.g., coronary revascularization patients with unstable symptoms).	IIb (A)
Management of blood resources	
Creation of multidisciplinary blood management teams (including surgeons, perfusionists, nurses, anesthesiologists, intensive care unit care providers, housestaff, blood bankers, cardiologists, etc.) is a reasonable means of limiting blood transfusion and decreasing perioperative bleeding while maintaining safe outcomes.	IIa (B)
Drugs used for intraoperative blood management	
Lysine analogues—epsilon-aminocaproic acid (Amicar) and tranexamic acid (Cyklokapron)—reduce total blood loss and decrease the number of patients who require blood transfusion during cardiac procedures and are indicated for blood conservation.	I (A)
High-dose (Trasylol, 6 million kallikrein inactivation unit [KIU]) and low-dose (Trasylol, 1 million KIU) aprotinin reduce the number of adult patients requiring blood transfusion, total blood loss, and reexploration in patients undergoing cardiac surgery but are not indicated for routine blood conservation because the risks outweigh the benefits. High-dose aprotinin administration is associated with a 49% to 53% increased risk of 30-day death and 47% increased risk of renal dysfunction in adult patients. No similar controlled data are available for younger patient populations including infants and children.	III (A)
Blood derivatives used in blood management	
Plasma transfusion is reasonable in patients with serious bleeding in context of multiple or single coagulation factor deficiencies when safer fractionated products are not available.	IIa (B)
For urgent warfarin reversal, administration of prothrombin complex concentrate (PCC) is preferred but plasma transfusion is reasonable when adequate levels of factor VII are not present in prothrombin complex concentrate.	IIa (B)
Transfusion of plasma may be considered as part of a massive transfusion algorithm in bleeding patients requiring substantial amounts of red-blood cells.	IIb (B)
Prophylactic use of plasma in cardiac operations in the absence of coagulopathy is not indicated, does not reduce blood loss and exposes patients to unnecessary risks and complications of allogeneic blood component transfusion.	III (A)
Plasma is not indicated for warfarin reversal in the absence of bleeding.	III (A)
Use of factor XIII may be considered for clot stabilization after cardiac procedures requiring cardiopulmonary bypass	IIb (C)

Table 2. Recommendations from Previously Published Blood Conservation Guidelines with Persistent Support in the Current Medical Literature

Recommendation	Class
Preoperative interventions	
Preoperative identification of high-risk patients (advanced age, preoperative anemia, small body size, noncoronary artery bypass graft or urgent operation, preoperative antithrombotic drugs, acquired or congenital coagulation/clotting abnormalities and multiple patient comorbidities) should be performed, and all available preoperative and perioperative measures of blood conservation should be undertaken in this group as they account for the majority of blood products transfused. (Level of evidence A)	I
Preoperative hematocrit and platelet count are indicated for risk prediction and abnormalities in these variables are amenable to intervention. (Level of evidence A)	I
Preoperative screening of the intrinsic coagulation system is not recommended unless there is a clinical history of bleeding diathesis. (Level of evidence B)	III
Patients who have thrombocytopenia (<50,000/mm^2), who are hyperresponsive to aspirin or other antiplatelet drugs as manifested by abnormal platelet function tests or prolonged bleeding time, or who have known qualitative platelet defects represent a high-risk group for bleeding. Maximum blood conservation interventions during cardiac procedures are reasonable in these high-risk patients. (Level of evidence B)	IIa
It is reasonable to discontinue low-intensity antiplatelet drugs (e.g., aspirin) only in purely elective patients without acute coronary syndromes before operation with the expectation that blood transfusion will be reduced. (Level of evidence A)	IIa

Recommendation	Class
Most high-intensity antithrombotic and antiplatelet drugs (including adenosine diphosphate-receptor inhibitors, direct thrombin inhibitors, low molecular weight heparins, platelet glycoprotein inhibitors, tissue-type plasminogen activator, streptokinase) are associated with increased bleeding after cardiac operations. Discontinuation of these medications before operation may be considered to decrease minor and major bleeding events. The timing of discontinuation depends on the pharmacodynamic half-life for each agent as well as the potential lack of reversibility. Unfractionated heparin is the notable exception to this recommendation and is the only agent which either requires discontinuation shortly before operation or not at all. (Level of evidence C)	IIb
Alternatives to laboratory blood sampling (e.g., oximetry instead of arterial blood gasses) are reasonable means of blood conservation before operation. (Level of evidence B)	IIa
Screening preoperative bleeding time may be considered in high-risk patients, especially those who receive preoperative antiplatelet drugs. (Level of evidence B)	IIb
Devices aimed at obtaining direct hemostasis at catheterization access sites may be considered for blood conservation if operation is planned within 24 hours. (Level of evidence C)	IIb
Transfusion triggers	
Given that the risk of transmission of known viral diseases with blood transfusion is currently rare, fears of viral disease transmission should not limit administration of INDICATED blood products. (This recommendation only applies to countries/blood banks where careful blood screening exists.) (Level of evidence C)	IIa
Transfusion is unlikely to improve oxygen transport when the hemoglobin concentration is greater than 10 g/dL and is not recommended. (Level of evidence C)	III
With hemoglobin levels below 6 g/dL, red blood cell transfusion is reasonable since this can be life-saving. Transfusion is reasonable in most postoperative patients whose hemoglobin is less than 7 g/dL but no high level evidence supports this recommendation. (Level of evidence C)	IIa
It is reasonable to transfuse nonred-cell hemostatic blood products based on clinical evidence of bleeding and preferably guided by point-of-care tests that assess hemostatic function in a timely and accurate manner. (Level of evidence C)	IIa
During cardiopulmonary bypass (CPB) with moderate hypothermia, transfusion of red cells for hemoglobin ≤6 g/dL is reasonable except in patients at risk for decreased cerebral oxygen delivery (i.e., history of cerebrovascular attack, diabetes, cerebrovascular disease, carotid stenosis) where higher hemoglobin levels may be justified. (Level of evidence C)	IIa
In the setting of hemoglobin values exceeding 6 g/dL while on CPB, it is reasonable to transfuse red cells based on the patient's clinical situation, and this should be considered as the most important component of the decision making process. Indications for transfusion of red blood cells in this setting are multifactorial and should be guided by patient-related factors (i.e., age, severity of illness, cardiac function, or risk for critical end-organ ischemia), the clinical setting (massive or active blood loss), and laboratory or clinical parameters (e.g., hematocrit, mixed venous oxygen saturation [SVO_2], electrocardiogram, or echocardiographic evidence of myocardial ischemia, etc.). (Level of evidence C)	IIa
It is reasonable to transfuse nonred-cell hemostatic blood products based on clinical evidence of bleeding and preferably guided by specific point-of-care tests that assess hemostatic function in a timely and accurate manner. (Level of evidence C)	IIa
It may be reasonable to transfuse red cells in certain patients with critical noncardiac end-organ ischemia (e.g., central nervous system and gut) whose hemoglobin levels are as high as 10 g/dL but more evidence to support this recommendation is required. (Level of evidence C)	IIb
In patients on CPB with risk for critical end-organ ischemia/injury, transfusion to keep the hemoglobin ≥7 g/dL may be considered. (Level of evidence C)	IIb
Drugs used for intraoperative blood management	
Use of 1-deamino-8-D-arginine vasopressin (DDAVP) may be reasonable to attenuate excessive bleeding and transfusion in certain patients with demonstrable and specific platelet dysfunction known to respond to this agent (e.g., uremic or CPB-induced platelet dysfunction, type I von Willebrand's disease). (Level of evidence B)	IIb
Routine prophylactic use of 1-deamino-8-D-arginine vasopressin is not recommended to reduce bleeding or blood transfusion after cardiac operations using CPB. (Level of evidence A)	III
Dipyridamole is not indicated to reduce postoperative bleeding, is unnecessary to prevent graft occlusion after coronary artery bypass	III

Recommendation	Class
grafting, and may increase bleeding risk unnecessarily. (Level of evidence B)	
Blood salvage interventions	
Routine use of red cell salvage using centrifugation is helpful for blood conservation in cardiac operations using CPB. (Level of evidence A)	I
During CPB, intraoperative autotransfusion, either with blood directly from cardiotomy suction or recycled using centrifugation to concentrate red cells, may be considered as part of a blood conservation program. (Level of evidence C)	IIb
Postoperative mediastinal shed blood reinfusion using mediastinal blood processed by centrifugation may be considered for blood conservation when used in conjunction with other blood conservation interventions. Washing of shed mediastinal blood may decrease lipid emboli, decrease the concentration of inflammatory cytokines, and reinfusion of washed blood may be reasonable to limit blood transfusion as part of a multimodality blood conservation program. (Level of evidence B)	IIb
Direct reinfusion of shed mediastinal blood from postoperative chest tube drainage is not recommended as a means of blood conservation and may cause harm. (Level of evidence B)	III
Perfusion interventions	
Open venous reservoir membrane oxygenator systems during cardiopulmonary bypass may be considered for reduction in blood utilization and improved safety. (Level of evidence C)	IIb
All commercially available blood pumps provide acceptable blood conservation during CPB. It may be preferable to use centrifugal pumps because of perfusion safety features. (Level of evidence B)	IIb
In patients requiring longer CPB times (>2 to 3 hours), maintenance of higher and/or patient-specific heparin concentrations during CPB may be considered to reduce hemostatic system activation, reduce consumption of platelets and coagulation proteins, and to reduce blood transfusion. (Level of evidence B)	IIb
Use of either protamine titration or empiric low dose regimens (e.g., 50% of total heparin dose) to lower the total protamine dose and lower the protamine/heparin ratio at the end of CPB may be considered to reduce bleeding and blood transfusion requirements. (Level of evidence B)	IIb
The usefulness of low doses of systemic heparinization (activated clotting time ~300 s) is less well established for blood conservation during CPB but the possibility of under-heparinization and other safety concerns have not been well studied. (Level of evidence B)	IIb
Acute normovolemic hemodilution may be considered for blood conservation but its usefulness is not well established. It could be used as part of a multipronged approach to blood conservation. (Level of evidence B)	IIb
Retrograde autologous priming of the CPB circuit may be considered for blood conservation. (Level of evidence B)	IIb
Postoperative care	
A trial of therapeutic positive end-expiratory pressure (PEEP) to reduce excessive postoperative bleeding is less well established. (Level of evidence B)	IIb
Use of prophylactic positive end-expiratory pressure to reduce bleeding postoperatively is not effective. (Level of evidence B)	III
Management of blood resources	
A multidisciplinary approach involving multiple stakeholders, institutional support, enforceable transfusion algorithms supplemented with point-of-care testing, and all of the already mentioned efficacious blood conservation interventions limits blood transfusion and provides optimal blood conservation for cardiac operations. (Level of evidence A)	I
A comprehensive integrated, multimodality blood conservation program, using evidence based interventions in the intensive care unit, is a reasonable means to limit blood transfusion. (Level of evidence B)	IIa
Total quality management, including continuous measurement and analysis of blood conservation interventions as well as assessment of new blood conservation techniques, is reasonable to implement a complete blood conservation program. (Level of evidence B)	IIa

Definitions:

Applying Classification of Recommendations and Level of Evidence

Size of Treatment Effect					
		CLASS I *Benefit >>> Risk* Procedure/Treatment SHOULD be performed/administered	CLASS IIa *Benefit >> Risk Additional studies with focused objectives needed* IT IS REASONABLE to perform procedure/administer treatment	CLASS IIb *Benefit ≥ Risk Additional studies with broad objectives needed; additional registry data would be helpful* Procedure/Treatment MAY BE CONSIDERED	CLASS III *Risk ≥ Benefit* Procedure/Treatment should NOT be performed/administered SINCE IT IS NOT HELPFUL AND MAY BE HARMFUL
Estimate of Certainty (Precision) of Treatment Effect	LEVEL A Multiple populations evaluated* Data derived from multiple randomized clinical trials or meta-analyses	• Recommendation that procedure or treatment is useful/effective • Sufficient evidence from multiple randomized trials or meta-analyses	• Recommendation in favor of treatment or procedure being useful/effective • Some conflicting evidence from multiple randomized trials or meta-analyses	• Recommendation's usefulness/efficacy less well established • Greater conflicting evidence from multiple randomized trials or meta-analyses	• Recommendation that procedure or treatment is not useful/effective and may be harmful • Sufficient evidence from multiple randomized trials or meta-analyses
	LEVEL B Limited populations evaluated* Data derived from a single randomized clinical trial or nonrandomized studies	• Recommendation that procedure or treatment is useful/effective • Evidence from single randomized trial or nonrandomized studies	• Recommendation in favor of treatment or procedure being useful/effective • Some conflicting evidence from single randomized trial or nonrandomized studies	• Recommendation's usefulness/efficacy less well established • Greater conflicting evidence from single randomized trial or nonrandomized studies	• Recommendation that procedure or treatment is not useful/effective and may be harmful • Evidence from single randomized trial or nonrandomized studies
	LEVEL C Very limited populations evaluated* Only consensus opinion of experts, case studies or standard of care.	• Recommendation that procedure or treatment is useful/effective • Only expert opinion, case studies, or standard of care	• Recommendation in favor of treatment of procedure being useful/effective • Only diverging expert opinion, case studies, or standard of care	• Recommendation's usefulness/efficacy less well established • Only diverging expert opinion, case studies, or standard of care	• Recommendation that procedure or treatment is not useful/effective and may be harmful • Only expert opinion, case studies, or standard of care

The above table is from the Methodology Manual for American College of Cardiology Foundation and American Heart Association (ACCF/AHA) Guideline Writing Committees.

*Data available from clinical trials or registries about the usefulness/efficacy in different subpopulations, such as gender, age, history of diabetes, history of prior myocardial infarction, history of heart failure, and prior aspirin use. A recommendation with Level of Evidence B or C does not imply that the recommendation is weak. Many important clinical questions addressed in the guidelines do not lend themselves to clinical trials. Even though randomized trials are not available, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

Clinical Algorithm(s)

None provided

Scope

Disease/Condition(s)

Perioperative bleeding requiring blood transfusion during cardiac operations

Guideline Category

Management

Prevention

Risk Assessment

Treatment

Clinical Specialty

Anesthesiology

Cardiology

Critical Care

Surgery

Thoracic Surgery

Intended Users

Physicians

Guideline Objective(s)

- To provide recommendations for practicing thoracic surgeons based on available medical evidence for blood conservation during cardiac operations
- To update the blood conservation guideline previously published in 2007 by the Society of Thoracic Surgeons

Target Population

Patients at risk of perioperative bleeding requiring blood transfusion during cardiac operations

Interventions and Practices Considered

Management/Treatment

1. Management of dual anti-platelet therapy before operation
2. Use of drugs that augment red blood cell volume or limit blood loss
3. Use of blood derivatives including fresh frozen plasma, factor XIII, leukoreduced red blood cells, platelet plasmapheresis, recombinant factor VII, antithrombin III, and factor IX concentrates
4. Blood salvage interventions
5. Use of minimally invasive procedures to limit perioperative bleeding and blood transfusion
6. Blood conservation related to extracorporeal membrane oxygenation and cardiopulmonary perfusion
7. Use of topical hemostatic agents
8. Management of resources through team interventions in blood management

Major Outcomes Considered

- Risk of bleeding/bleeding rates
- Blood volume loss
- Blood transfusion rates
- Mortality
- Thrombotic complications
- Rate of postoperative anemia

Methodology

Methods Used to Collect/Select the Evidence

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

The search methods used to survey the published literature changed in the current version compared with the previously published guideline. In the interest of transparency, literature searches were conducted using standardized MeSH terms from the National Library of Medicine PubMed database list of search terms. The following terms comprised the standard baseline search terms for all topics and were connected with the logical "OR" connector: extracorporeal circulation (MeSH number E04.292 includes extracorporeal membrane oxygenation [ECMO], left heart bypass, hemofiltration, hemoperfusion, and cardiopulmonary bypass), cardiovascular surgical procedures (MeSH number E04.100 includes OPCABG, CABG, myocardial revascularization, all valve operations, and all other operations on the heart), and vascular diseases (MeSH number C14.907 includes dissections, aneurysms of all types including left ventricular aneurysms, and all vascular diseases). Use of these broad search terms allowed specific topics to be added to the search with the logical "AND" connector. This search methodology provided a broad list of generated references specific for the search topic. Only English language articles contributed to the final recommendations. For almost all topics reviewed, only evidence relating to adult patients entered into the final recommendations, primarily because of limited availability of high-quality evidence relating to pediatric patients having cardiac procedures.

Number of Source Documents

Not stated

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Applying Classification of Recommendations and Level of Evidence

Size of Treatment Effect					
		CLASS I *Benefit >>> Risk* Procedure/Treatment SHOULD be performed/administered	CLASS IIa *Benefit >> Risk Additional studies with focused objectives needed* IT IS REASONABLE to perform procedure/administer treatment	CLASS IIb *Benefit ≥ Risk Additional studies with broad objectives needed; additional registry data would be helpful* Procedure/Treatment MAY BE CONSIDERED	CLASS III *Risk ≥ Benefit* Procedure/Treatment should NOT be performed/administered SINCE IT IS NOT HELPFUL AND MAY BE HARMFUL
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	LEVEL C Very limited populations	• Recommendation that procedure or treatment is useful/effective	• Recommendation in favor of treatment of procedure being	• Recommendation's usefulness/efficacy less well established	• Recommendation that procedure or treatment is not useful/effective

Size of Treatment Effect	evaluated*	• Only expert opinion, case studies, or standard of care	useful/effective • Only diverging expert opinion, case studies, or standard of care	• Only diverging expert opinion, case studies, or standard of care	and may be harmful • Only expert opinion, case studies, or standard of care
	Only consensus opinion of experts, case studies or standard of care.				

The above table is from the Methodology Manual for American College of Cardiology Foundation and American Heart Association (ACCF/AHA) Guideline Writing Committees.

*Data available from clinical trials or registries about the usefulness/efficacy in different subpopulations, such as gender, age, history of diabetes, history of prior myocardial infarction, history of heart failure, and prior aspirin use. A recommendation with Level of Evidence B or C does not imply that the recommendation is weak. Many important clinical questions addressed in the guidelines do not lend themselves to clinical trials. Even though randomized trials are not available, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

Methods Used to Analyze the Evidence

Review of Published Meta-Analyses

Systematic Review

Description of the Methods Used to Analyze the Evidence

Not stated

Methods Used to Formulate the Recommendations

Expert Consensus

Description of Methods Used to Formulate the Recommendations

The Society of Thoracic Surgeons Workforce on Evidence Based Surgery provides recommendations for practicing thoracic surgeons based on available medical evidence. Part of the responsibility of the Workforce on Evidence Based Surgery is to continually monitor published literature and to periodically update recommendations when new information becomes available. The updated guideline document represents the first revision of a guideline by the Workforce and deals with recent new information on blood conservation associated with cardiac operations. This revision contains new evidence that alters or adds to the 61 previous recommendations that appeared in the 2007 Guideline.

Members of the writing group, assigned to a specific topic, made recommendations about blood conservation and blood transfusion associated with cardiac operations based on review of important articles obtained using this search technique. The quality of information on a given blood conservation topic allowed assessment of the level of evidence as recommended by the American College of Cardiology Foundation and American Heart Association (ACCF/AHA) Task Force on Practice Guidelines and listed in the "Rating Scheme for the Strength of Evidence" field.

Writers assigned to the various blood conservation topics wrote and developed new or amended recommendations, but each final recommendation that appears in this revision was approved by at least a two-thirds majority favorable vote from all members of the writing group. Appendix 1 of the original guideline document contains the results of the voting for each recommendation, and explains any major individual dissensions.

Rating Scheme for the Strength of the Recommendations

See the "Rating Scheme for the Strength of the Evidence" field, above.

Cost Analysis

Published cost-effectiveness analyses were reviewed.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

Not stated

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The type of supporting evidence is identified and graded for each recommendation (see the "Major Recommendations" field).

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

- Interventions aimed at reducing bleeding and blood transfusion during cardiac procedures are an increasingly important part of quality improvement and are likely to provide benefit to the increasingly complex cohort of patients undergoing these operations.
- Patients at highest risk for bleeding will likely benefit from recommended interventions by conserving valuable blood resources and limiting transfusion.

Potential Harms

Benefits of any of the blood conservation interventions must be weighed against potential risks, including thrombotic complications and the risks associated with transfusion of blood products.

Contraindications

Contraindications

BioGlue is specifically contraindicated in growing tissue, limiting its use in pediatric procedures.

Qualifying Statements

Qualifying Statements

- The Society of Thoracic Surgeons Clinical Practice Guidelines are intended to assist physicians and other health care providers in clinical decision-making by describing a range of generally acceptable approaches for the diagnosis, management, or prevention of specific diseases

or conditions. These guidelines should not be considered inclusive of all proper methods of care or exclusive of other methods of care reasonably directed at obtaining the same results. Moreover, these guidelines are subject to change over time, without notice. The ultimate judgment regarding the care of a particular patient must be made by the physician in light of the individual circumstances presented by the patient.

- Two limitations to the current body of literature on the topic of salvaging post-cardiopulmonary bypass (CPB) extracorporeal circuit (ECC) blood are noteworthy: (1) most of the current literature focuses on elective coronary artery bypass graft surgery (CABG) patients; and (2) many studies include small sample sizes. From the available literature, no firm distinction among these techniques for salvaging post-CPB ECC blood arises. Additional studies are required to clarify the effectiveness and efficacy of these approaches to pump salvage. However, consensus supports the practice of pump salvage compared with no salvage of residual blood.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

Staying Healthy

IOM Domain

Effectiveness

Safety

Identifying Information and Availability

Bibliographic Source(s)

Ferraris VA, Brown JR, Despotis GJ, Hammon JW, Reece TB, Saha SP, Song HK, Clough ER, Shore-Lesserson LJ, Goodnough LT, Mazer CD, Shander A, Stafford-Smith M, Waters J, Baker RA, Dickinson TA, Fitzgerald DJ, Likosky DS, Shann KG. 2011 update to the Society of Thoracic Surgeons and the Society of Cardiovascular Anesthesiologists blood conservation clinical practice guidelines. Ann Thorac Surg. 2011 Mar;91(3):944-82. [404 references] PubMed

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

2007 May (revised 2011 Mar)

Guideline Developer(s)

Society of Cardiovascular Anesthesiologists - Medical Specialty Society

Society of Thoracic Surgeons - Medical Specialty Society

Source(s) of Funding

Society of Thoracic Surgeons

Guideline Committee

Society of Thoracic Surgeons Workforce on Evidence Based Surgery

Composition of Group That Authored the Guideline

The Society of Thoracic Surgeons Blood Conservation Guideline Task Force: Victor A. Ferraris, MD, PhD (*Chair*); Jeremiah R. Brown, PhD; George J. Despotis, MD; John W. Hammon, MD; T. Brett Reece, MD; Sibu P. Saha, MD, MBA; Howard K. Song, MD, PhD; and Ellen R. Clough, PhD

The Society of Cardiovascular Anesthesiologists Special Task Force on Blood Transfusion: Linda J. Shore-Lesserson, MD; Lawrence T. Goodnough, MD; C. David Mazer, MD; Aryeh Shander, MD; Mark Stafford-Smith, MD; and Jonathan Waters, MD

The International Consortium for Evidence Based Perfusion: Robert A. Baker, PhD, Dip Perf, CCP (Aus); Timothy A. Dickinson, MS; Daniel J. FitzGerald, CCP, LP; Donald S. Likosky, PhD; and Kenneth G. Shann, CCP

Financial Disclosures/Conflicts of Interest

Author Disclosures of Industry Relationships			
Author	Disclosure	Lecture Fees, Consultant, Paid Work From Industry within 12 Months	Research Grant Support From Industry within 12 Months
V. A. Ferraris	No	None	None
S. P. Saha	Yes		Baxter
J. Waters	Yes	Biotronics	Sorin Group
A. Shander	Yes	Bayer, Luitpold, Masimo, Novartis, NovoNordisk, OrthoBiotech, Zymogenetics	Bayer, Novartis, NovoNordisk, OrthoBiotech, Pfizer, ZymoGenetics
L. T. Goodnough	Yes	Eli Lilly, CSL Behring, Luitpold, Amgen	
L. J. Shore-Lesserson	Yes	CSL Behring, NovoNordisk	
K. G. Shann	No		
G. J.	Yes	Genzyme, CSL Behring, Zymogenetics, Bayer, Cubist, SCS	

Author Disclosures of Industry Relationships

Author	Disclosure	Nature	Research Grants Received From Industry within 12 Months
Despotis, G.	Yes	Healthcare, Telacris, Eli Lilly, Medtronic, ROTEM, NovoNordisk, Biotrack, HemoTech, Genzyme/GTC	AstraZeneca, Orthopedic Acute Kidney Injury
J. R. Brown	Yes	Nature Fees, Consultant, Paid Work From Industry within 12 Months	RHBQ1CHS10443 From Industry within 12 Months
J. W. Hammon	Yes	Medtronic, St. Jude Medical	
C. D. Mazer	Yes	NovoNordisk, Oxygen Biotherapeutics, Cubist	NovoNordisk, Cubist
R. A. Baker	Yes		Terumo Cardiovascular; Lunar Innovations; Cellplex Pty Ltd, Somanetics
D. S. Likosky	Yes		AHRQ; Maquet Cardiovascular; Somanetics Corporation; Sorin Biomedica; Terumo Cardiovascular Systems; Medtronic
T. A. Dickinson	Yes	SpecialtyCare, Inc	
D. J. FitzGerald	No		
H. K. Song	Yes		NovoNordisk A/S
T. B. Reece	No		
M. Stafford-Smith	Yes	PolyMedix, Inc	
E. R. Clough	No		

Guideline Endorser(s)

International Consortium for Evidence-based Perfusion - Professional Association

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Society of Thoracic Surgeons Blood Conservation Guideline Task Force, Ferraris VA, Ferraris SP, Saha SP, Hessel EA 2nd, Haan CK, Royston BD, Bridges CR, Higgins RS, Despotis G, Brown JR; Society of Cardiovascular Anesthesiologists Special Task Force on Blood Transfusion, Spiess BD, Shore-Lesserson L, Stafford-Smith M, Mazer CD, Bennett-Guerrero E, Hill SE, Body S. Ann Thorac Surg. 2007 May;83(5 Suppl):S27-86.

Guideline Availability

Electronic copies: Available in Portable Document Format (PDF) from the Society of Thoracic Surgeons Web site .

Print copies: Available from The Society of Thoracic Surgeons, 633 N. Saint Clair St., Suite 2320, Chicago, IL, USA 60611-3658

Availability of Companion Documents

None available

Patient Resources

None available

NGC Status

This NGC summary was completed by ECRI Institute on April 6, 2011. This summary was updated by ECRI Institute on March 10, 2014 following the U.S. Food and Drug Administration advisory on Low Molecular Weight Heparins.

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